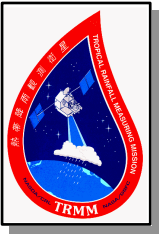
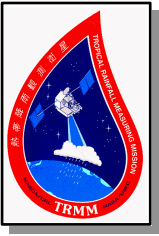


TRMM Receiving Review



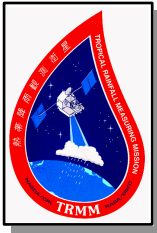
Introduction

- Spacecraft
 - Launched with ETS-VII on November 27 (97-331) at 21:27:00z on an H-II from Tanegashima, Japan
 - » Four previous delays
 - » 2 months of L&IOC
 - Earth pointing, 3-Axis stabilized, at 35° inclined frozen orbit
 - 5 Instruments (a priori): PR, TMI, VIRS, CERES, LIS
 - +Y side of the spacecraft kept out of sun

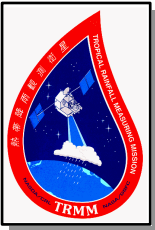


Introduction

- Operations
 - 2 person shifts; around-the-clock coverage
 - Orbit boosts approximately every 6 days; Yaws vary with Beta angle
 - 15-17 passes daily, 20 minutes each
 - » Most are high rate recorder dumps
 - » Non-coherent transponder trending passes each day
 - EPVs and stored loads daily

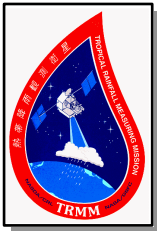


Spacecraft Subsystems



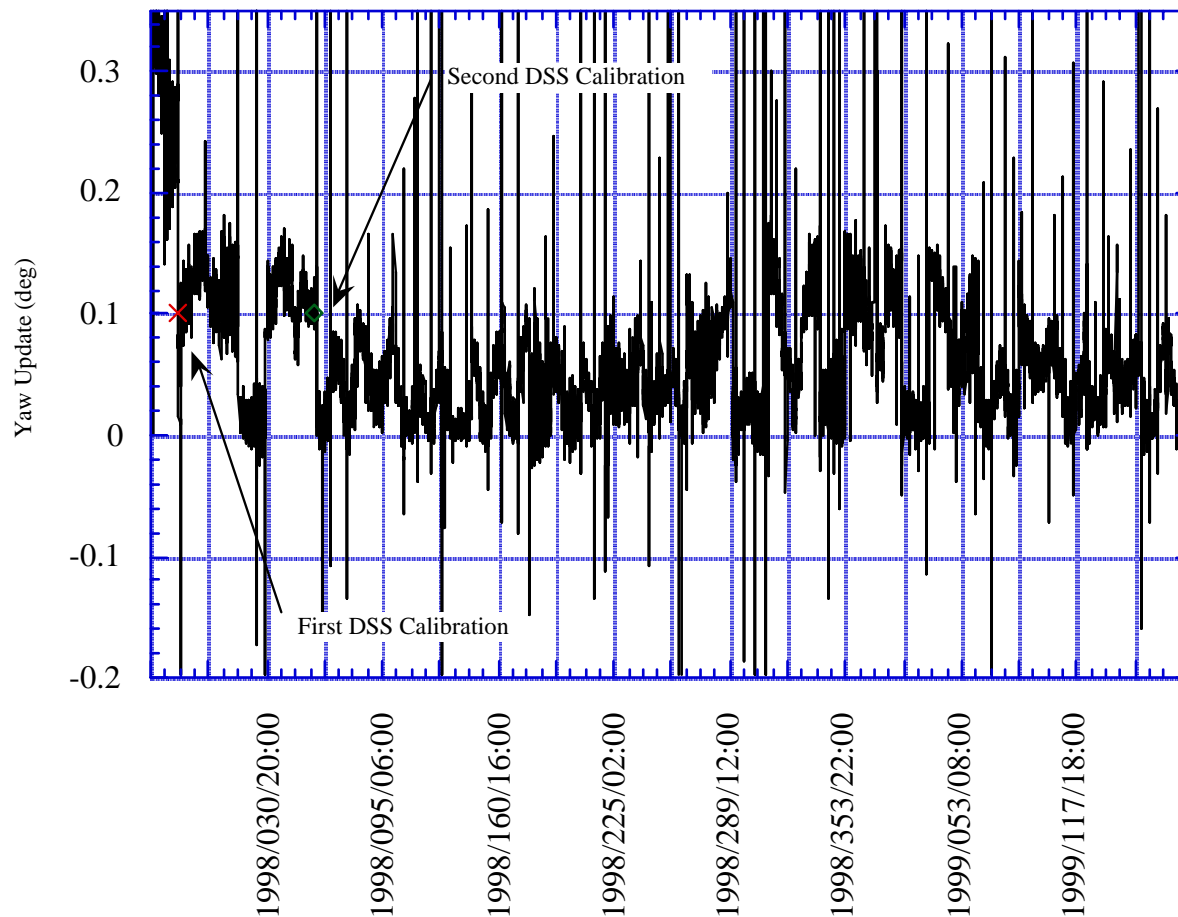
ACS Subsystem

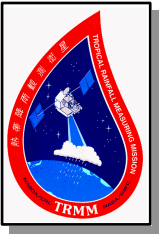
- 2 Sun Acq occurrences occurred since launch - limits set too tight; no actual problems with spacecraft
- Solar Array jitter (AR #74)
 - Experienced above $\pm 54^\circ$
 - Possible corrective action: ACS software patch (CCR #052)
 - » Change Solar Array Sun tracking code
 - Computations of the Sun position in the SA frame will use nominal Sun position based on the nominal attitude
- Yaw updates show seasonal changes
 - » Changes desired by September to remain within 1σ specifications



ACS Subsystem

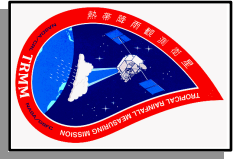
Yaw Updates Since Launch





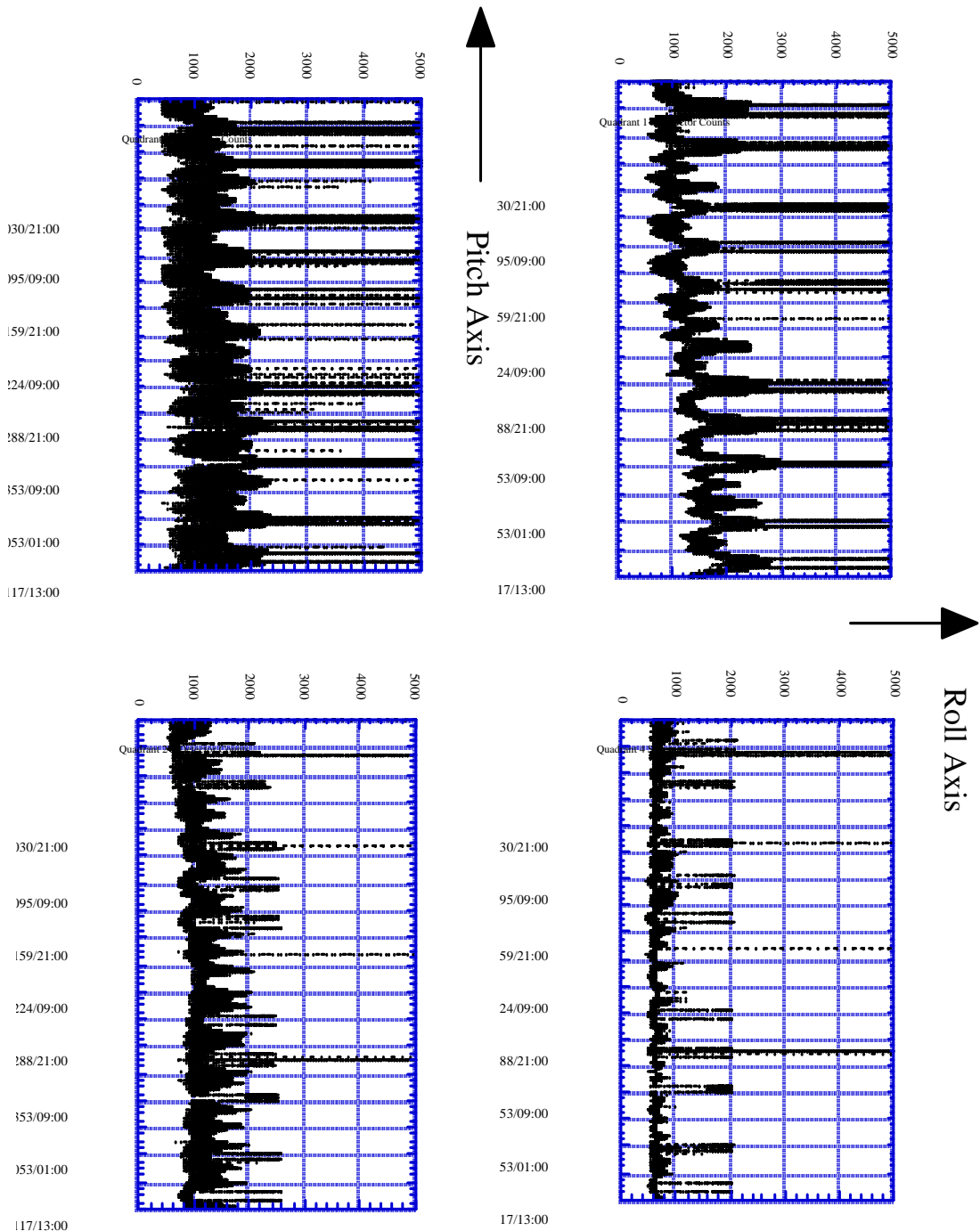
ACS Subsystem

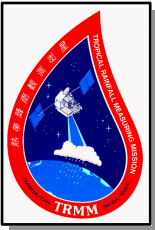
- TDRS EPVs still sometimes fail in position and velocity following TDRS maneuvers (AR #60 - CCR #035)
 - » New table 85 with updated position & velocity limits generated and tested at the STTF
 - Position Limit increased from 400 to 850 km
 - Velocity Limit increased from 0.3 to 0.62 km/s
- ESA fogging
 - Focused in Quadrant 1
 - Action threshold is ~2500 counts
 - » Look into table bias changes
 - » Start thinking about Contingency Mode (checked out during L&IOC)
 - Manufacturer (Barnes) is not concerned with current performance



ACS Subsystem

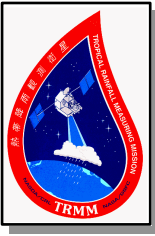
ESA S Counts per Quadrant





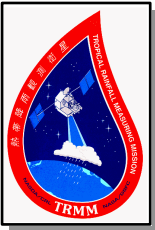
ACS Subsystem

- Potential Failure of -Y solar array
 - » Contingency plan to fire one-shot thruster pulses if necessary
 - » ACS NASA engineers finished testing of stopped array scenario with yaw maneuver and failed reaction wheel
 - » ACE RAM patch delivery needed to reduce torque gain in Safehold
 - » Looking into the possibility of uplinking new ACS tables 54&66 now, possibly with adjusted values (CCR #042)
 - » Looking into the possibility of pitching spacecraft to warm PR in Safehold or Sun Acq
- Adjustment of HW Eclipse Transition Deadband (CCR #003)
 - Awaiting FSW action to update documentation for closure
- Correction for Magnetic Field Epoch (CCR #005)
 - Awaiting ACS (Code 571&572) verification to update EEPROM



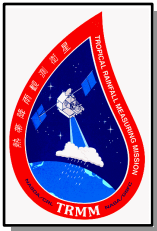
ACS Subsystem

- Update software for non-orthogonal DSS (CCR #008)
 - Awaiting outcome of current plan to perform calibration for Yaw Updates
- Redundant IRU Calibrations (CCR #026)
 - Tables are ready to be built on MOC system if needed
- Contingency Mode DSS Calibrations (CCR #027)
 - Tables are ready to be built on MOC system if needed
- Abort ACS ATS if Burn Aborted (CCR #033)
 - Checksheet modified to ensure $< 60s$ burns

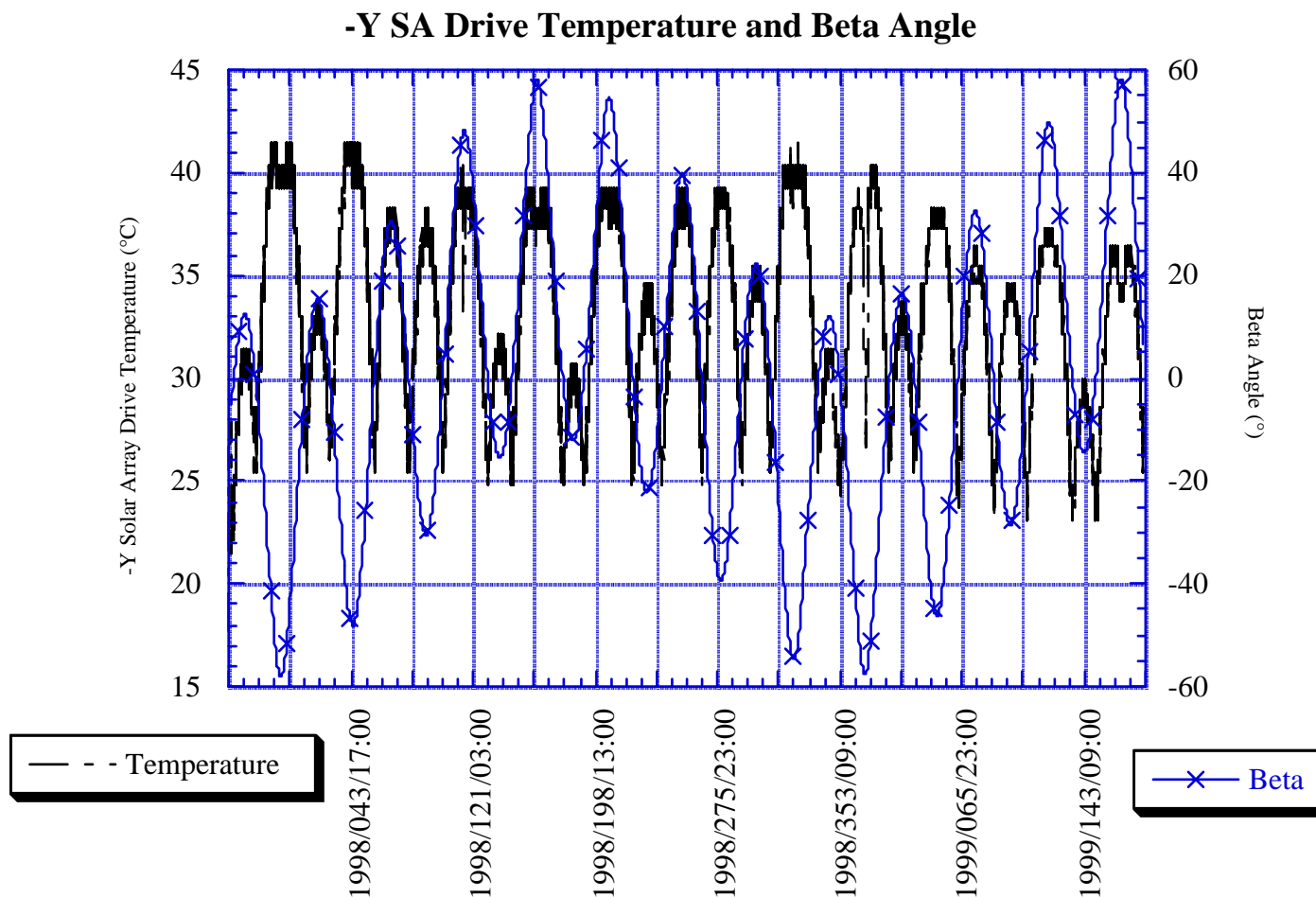


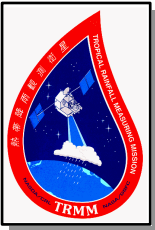
Deployables Subsystem

- -Y solar array drive temperature
 - A 10° C increase in temperature is 100 times more likely to evaporate the lubricant and may potentially cause undetected levels of metal particles
 - Bearing temperature cannot be measured directly
 - Reaches maximum temperature at beta angle ~48°
 - YH temperature: 42° C; Life test temperature: 37° C
 - » Came within 0.5° C of yellow high temperature



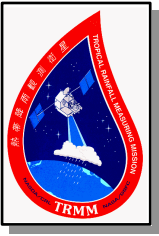
Deployables Subsystem





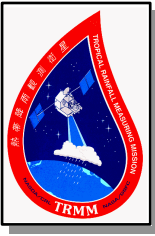
Deployables Subsystem

- -Y Solar Array Readiness Review
 - Rejected parking the -Y solar array at 30° and remain status quo
 - » Determined that power management would have to be done at certain beta angles/seasons regardless of decision
 - Life test on drive motor will not be performed, test would still be inconclusive in determining whether solar array drive will fail
 - FOT Training now focuses on solar array failure identification and early contingency steps
 - Detection of Failed Array
 - » Checklist
 - » TSMs for sensed vs commanded position
- HGA antenna
 - No loss of RF lock during Delta-V and Yaw maneuvers



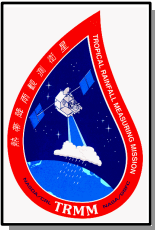
RCS Subsystem

- Delta-V Maneuvers
 - Only two since launch not completed due to constraints set too tight
- Delta-V Operations
 - Three Delta-V operational changes introduced since launch
 - » Maneuver scheduling changed to every 4th day (#74 - #87)
 - » Burns no longer limited to integer seconds (starting with #82)
 - » Catbed heater on-time from 91 to 45 min (starting with #99)



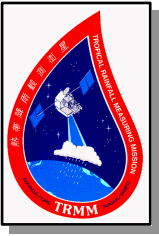
RCS Subsystem

- Fuel Budget Analysis:
 - Current estimate is 6.4 years from launch (was 3 years)
 - » Predicted: 170 psia; Observed: 167.7 psia
 - » Thruster performance 5% better than pre-launch estimates
 - » Solar Flux levels in 98 and 99 lower than predicted
 - » 50 kg reserve used in estimates - 150 kg might be needed
 - Spreadsheet developed by FOT with RCS Code 713 engineers
 - » outputs expected life by relating average daily fuel consumption with predicted solar flux levels - updated monthly



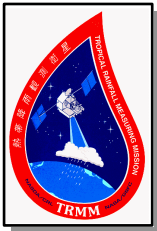
RCS Subsystem

- End of Life Status from FDF Analysis (2 options)
 - End science mission at 118 kg fuel
 - » 5 to 8 week orbit decay phase to 200 km, then controlled reentry using 55 kg of fuel; some FOT support needed throughout
 - End science mission at 150 kg - controlled reentry from mission mode
- Performance Issues
 - Thruster misalignments minimal and well understood
 - » ISP burns: -Pitch (#6) off-modulates 30-35% (0% roll pulsing)
 - » LBS burns: +Pitch (#2) off-modulates 15-20%
 - Yaw (#1) off-modulates 5-8% (0% roll pulsing)
 - LBS burns sometimes have 1-2 second plateau in pitch momentum 7 seconds into first burn - no operational impact



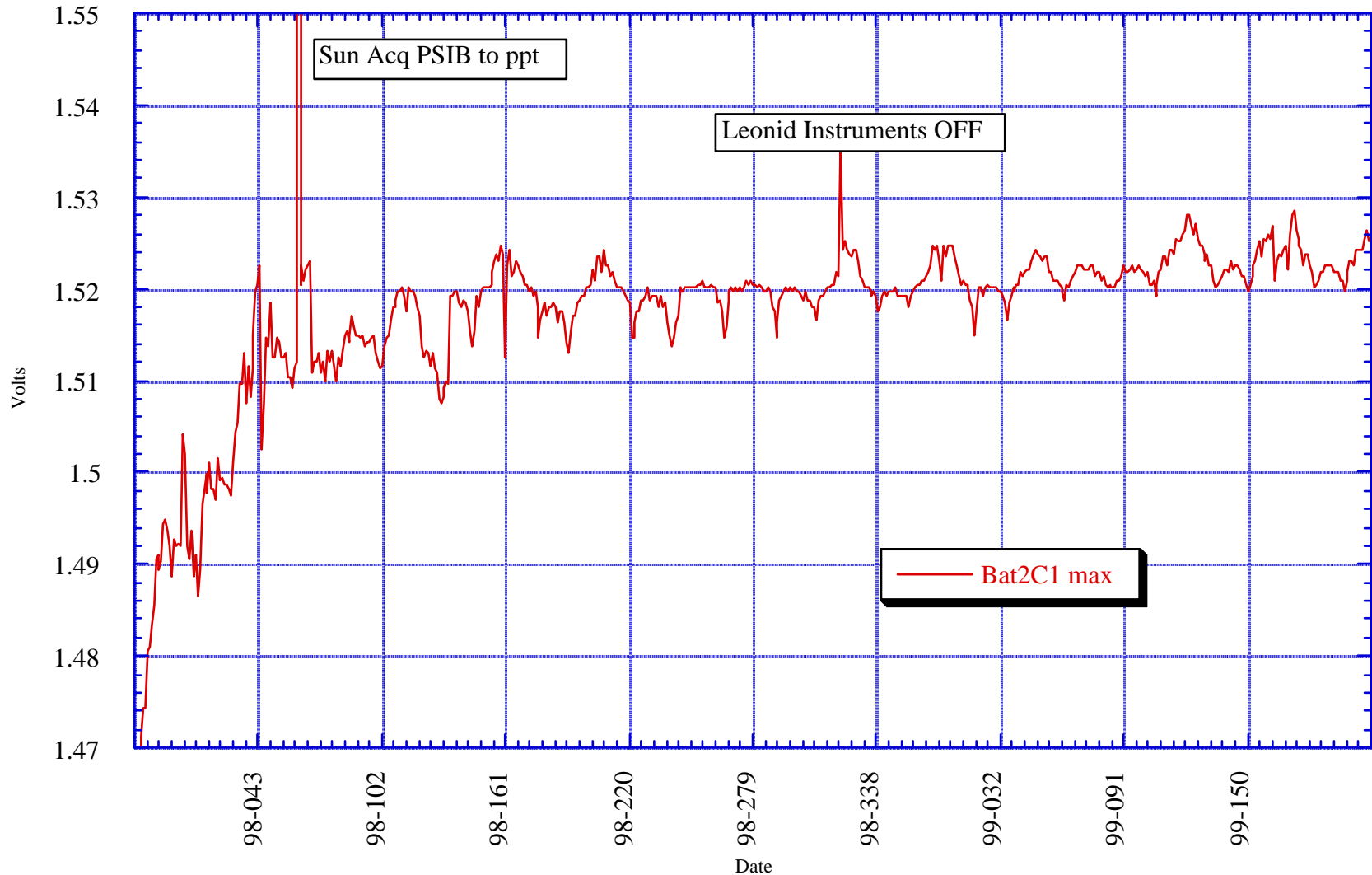
Power Subsystem

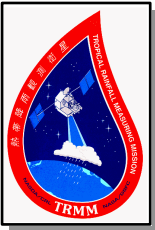
- Power analysis reports and trending provided to Code 563
- State of Charge counters not reaching 100% for all orbits at low Beta angles
 - CD changed to 1.02 on 99-138 after TSMs # 31 and 32 limits reached
- Battery 2 Cell 1 Anomaly high cell voltage (on 98-028)
 - On 98-062, PSIB B turned on to rule out telemetry problem
 - TSMs #31 - 34 and RTS #13 added to prevent PSIB mis-configuration (EOD SOC drops below 95%)



Power Subsystem

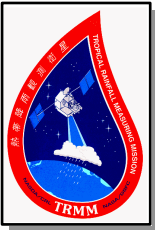
Battery 2 Cell 1 Daily Maximum





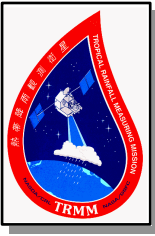
Power Subsystem

- Open Anomalies
 - #55 Battery 2 Cell 1 hitting limits on 98-028
 - » Manufacturer has not given satisfactory answer to close report
 - #73 PSIB tick counter stopped incrementing on 99-138
 - » Flight Software working on a PSIB code patch to correct several routines found to have faulty logic (CCR #49 and 50)
- Open Issues
 - Solar Array failure may affect power charge settings
 - » Shedding additional loads plan (other than NESS bus)
 - » Prioritizing power draws



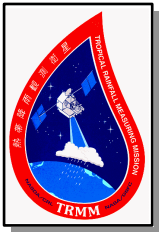
Electrical Subsystem

- Future Projects
 - To investigate the long term impact of CERES power cycling on the subsystem (No impact seen so far)
 - Development of CERES current TSM (CCR #045)



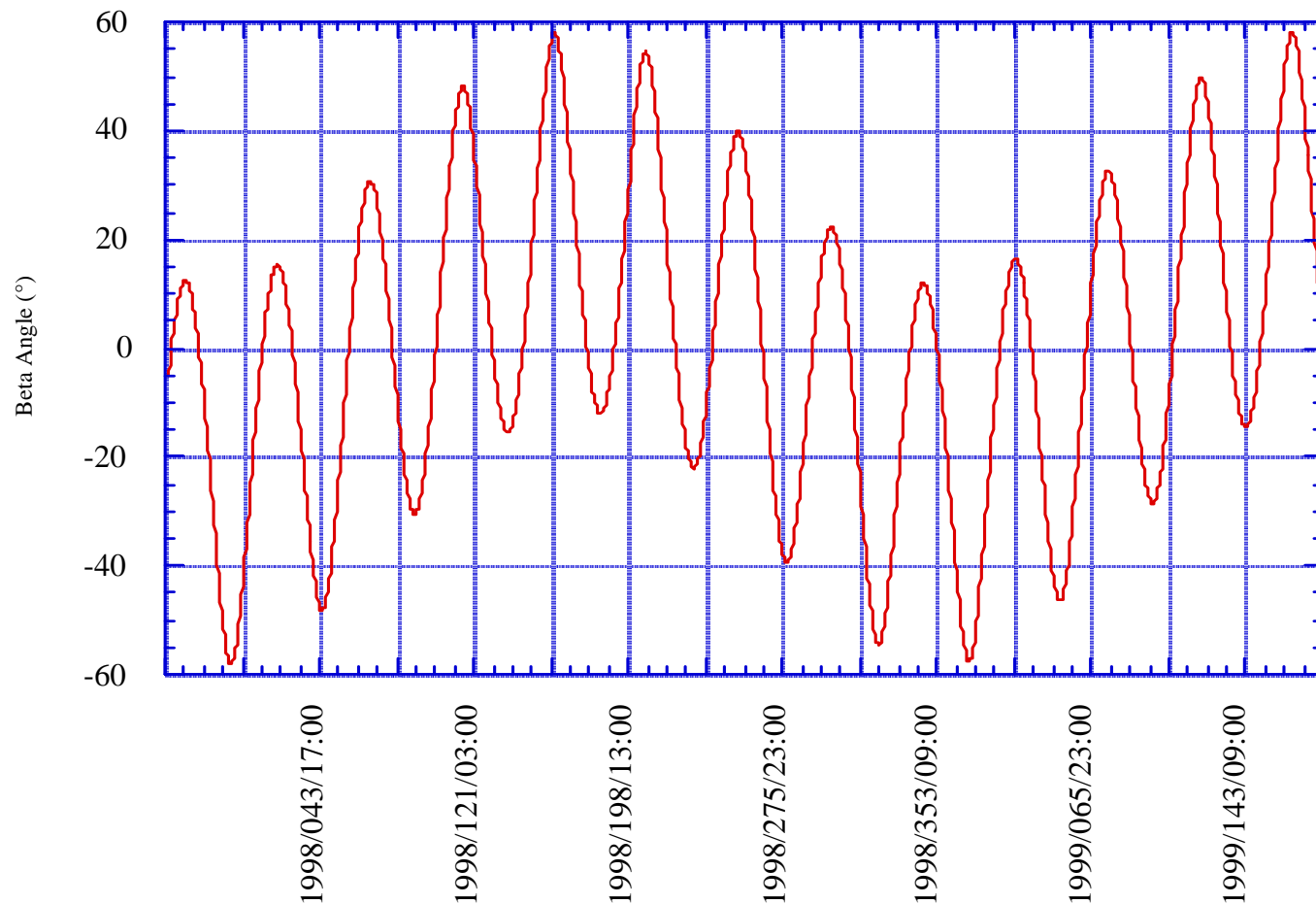
Thermal Subsystem

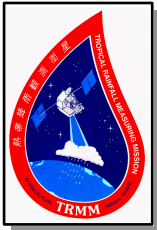
- Solar Beta angle cycle:
 - Biggest influence on thermal behaviors
 - Two peaks a year at $+58^\circ$ and -58°
- High thermal conditions experienced on solar array drive remains a serious concern
- Open Issues
 - If Spacecraft is pitched for PR in Sun Acq/Safehold, how will other subsystems be affected?



Thermal Subsystem

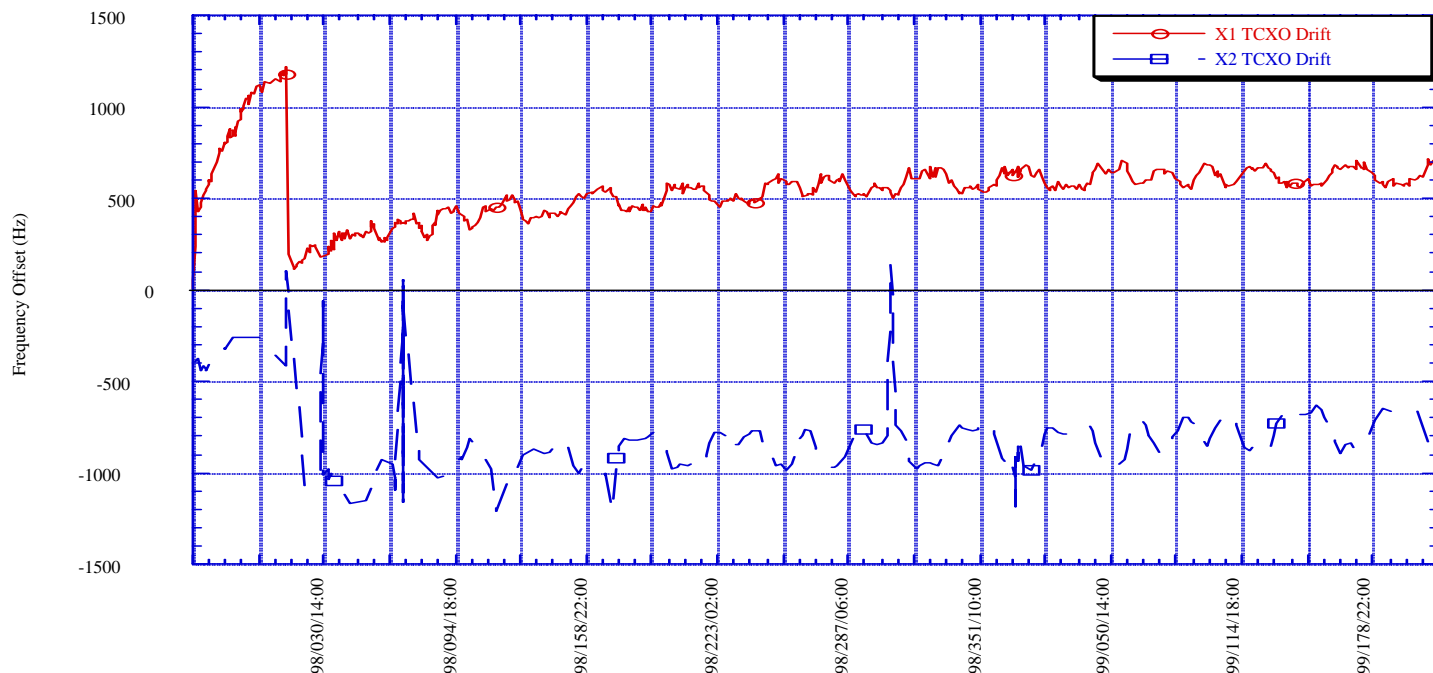
Beta Angle Since Launch (97/331-99/181)



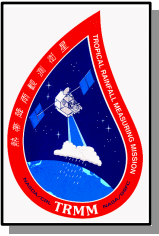


RF Subsystem

- Frequencies settled at ± 700 Hz
 - XP1 trended once a day, XP2 three times a week

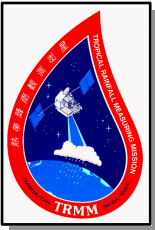


- Generic Late Acquisitions
 - No indication of subsystem problem
 - Mostly seen on TDRS West



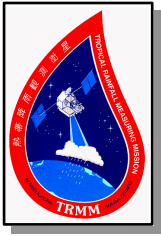
FDS Subsystem

- UTCF allowed to drift full range of requirement ($\sim 900 \mu s$)
- Caveats of the system
 - Q-channel Restarts: can't handle odd frame
 - Flywheels (AR #51): lower half of orbit
 - Memory Scrub task (MS) Not Present: release of large datasets
- Writing from RAM to EEPROM (CCR #034)
 - Awaiting CERES modifications
- Eliminate all Launch Monitors (CCR #039)
- DS filter table change to record more ACE data (CCR #048)

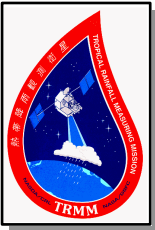


C&DH Subsystem

- No-clock software patch developed, though no indication of anomaly on FS B (CCR #047)
 - Simulator being upgraded with ACS components to improve testing
- FS exhibits strong negative drift
 - Loses $\sim 0.1 \mu\text{s/hr/day}$
- 1773 Bus behaves as expected in atmospheric conditions
 - Retries: S/C= 1.0/d, ACS= 0.25/d, Inst= 1.5/d
 - Bit errors: Single= 55/d, Multi= 1 every 3 days

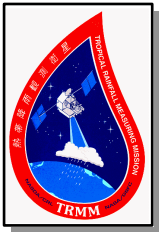


Instruments



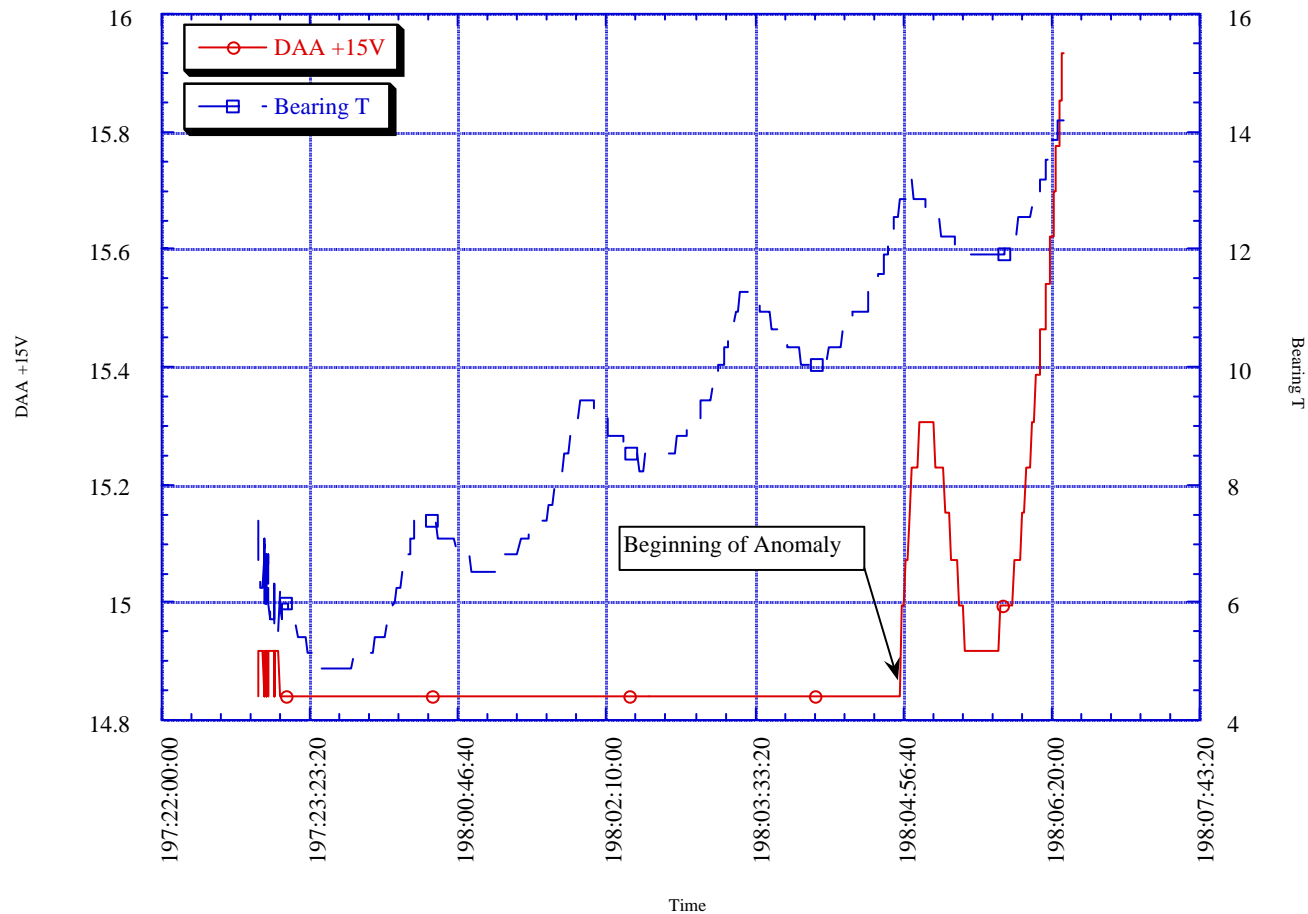
CERES Instrument

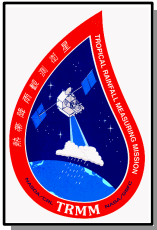
- Instrument has been powered OFF two times since Launch due to spacecraft anomalies
- AR #69: +15 V DAA converter voltage hit high limits on 98-230
 - Powered OFF 98-244
 - Powered ON for short periods to coordinate science testing with other instruments and ground sites: ScaRaB instrument, INDOEX, Hawaii, and Australia
 - The LaRC *CERES +15V Anomaly Report* details the cause of the converter failure
 - Will turn on for calibrations until a permanent turn ON post TERRA launch



CERES Instrument

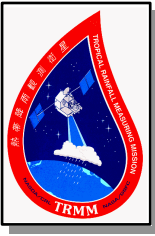
CERES DAA +15V Voltage vs. Bearing Temperature





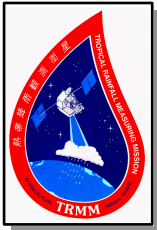
CERES Instrument

- Open Issues
 - Removing CERES from ACS contingency load-shed
 - » Plan developed
 - » Modifications almost complete



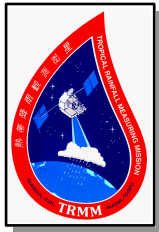
LIS Instrument

- Instrument has been powered OFF four times since Launch
- MSFC Command Requests
 - Reset instrument to reduce data sequence errors, approximately once a month
 - » The maximum number of science packets are being received



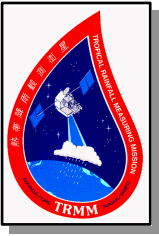
PR Instrument

- Instrument has been powered OFF four times since Launch
- Operations Change
 - PR K1 relay for the survival heater are opened before all instrument power ONs to prevent instrument overheating; the relay remains open until 48 hours after turn on (TIL #1198J)



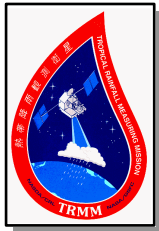
PR Instrument

- Open Issues
 - Possibility of opening PR survival heater relays to ensure power positive state in Sun Acq or Safehold if the -Y array fails
 - » Documents indicate that the lowest Qualifying Temperature of the components in a non-operating condition is -30°C
 - Have seen low temperatures of approximately -22° in past Sun Acq anomalies which is the turn-on setpoint for the -Y panel PR survival heater
 - Frequency agreement
 - » Runs out at the end of 2000
 - What new restriction will it place on the operation of PR
 - Possibility of extension



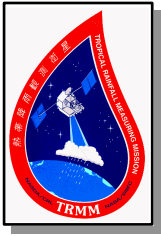
TMI Instrument

- Instrument has been powered OFF four times since Launch
- Deep Space Calibration (Inertially Fixed Mode) done on 98-245 to determine source of interference seen in the science data
 - Determined that PR was not the source
 - Interference is currently being masked out in ground processing
 - Currently no other calibrations are planned because of risk to VIRS (thermal short)

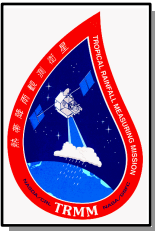


VIRS Instrument

- Instrument has been powered off 4 times since Launch
- 8 Self-resets since launch
 - Anomaly #56 (VIRS Resets)
 - » Still open and will be classified in the SOAR database as “INACTIVE”
 - An LOP and a recovery procedure have been developed
- Radiative Cooler (Inner Cold Stage)
 - Thermal shorts experienced during Deep Space Cals and Sun Acquisition is a result of the quick heating of the Cold stage
 - » 3 out of 4 Outgas operations performed since launch to correct thermal short



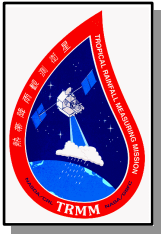
Requirements



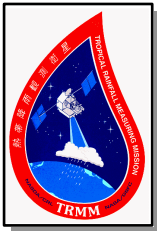
Requirements

Performance Summary

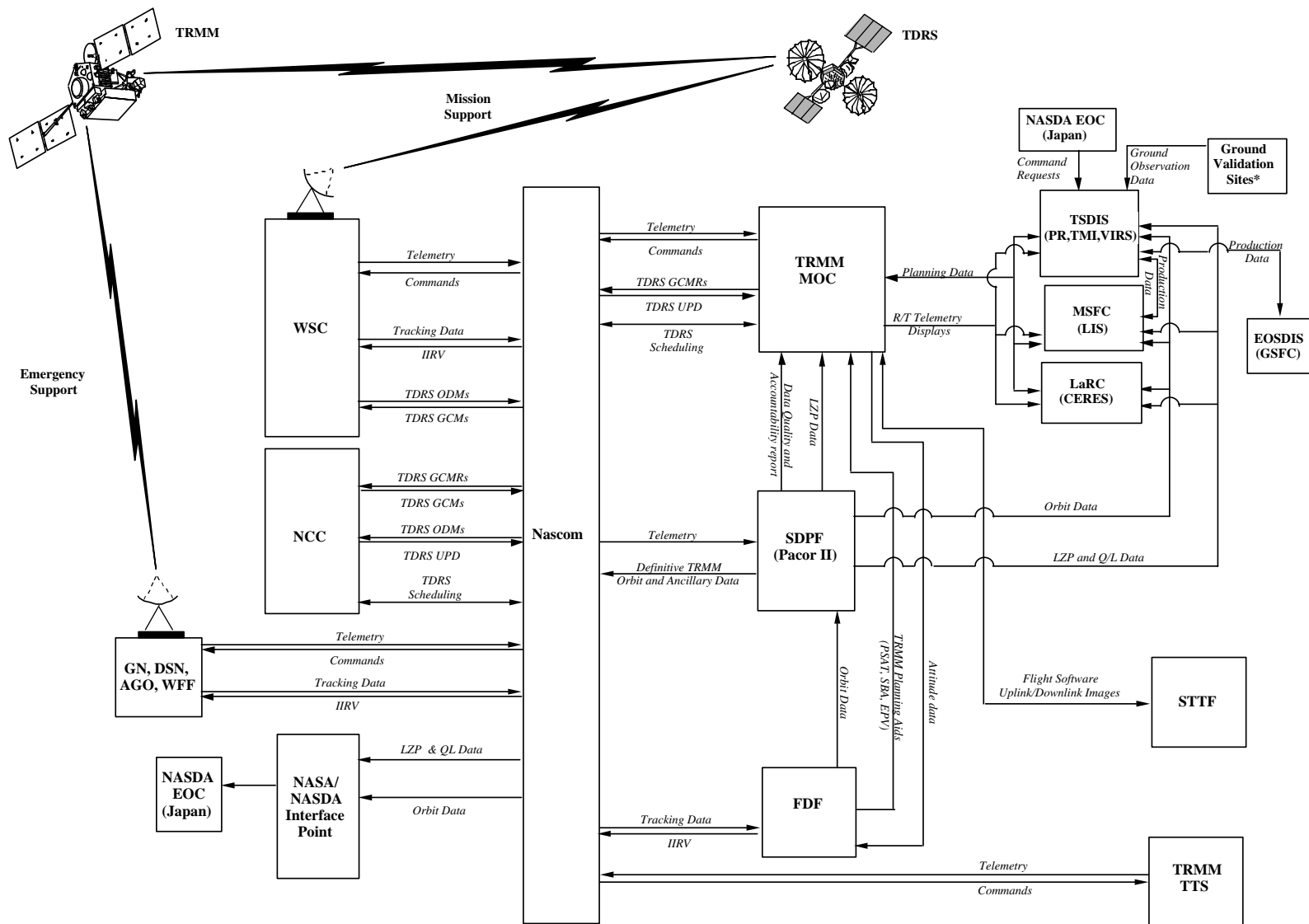
Parameters	Requirements	June 99
Altitude	350 ± 1.25 km	350 ± 1.25 km
Life	3 years	6.6 years
Inclination	35 ± 0.1 degrees	34.98 degrees
Eccentricity	0.00054 ± 0.0001	0.000525
Launch Mass	3523 kg	3347.7340 kg
Fuel (Hydrazine)	890.0389 kg	716.8458 kg
Mission Power (Load)	1100 W	750 W
Data Capture	97 %	99.3 %
Frequency (fwd link)	2076.94 MHz	2076.94 MHz
Frequency (rtn link)	2255.5 MHz	2255.5 MHz
Fwd Data Rates (kbps)	0.5, 1, 2	0.5, 1, 2
Rtn Data Rates (kbps)	1, 1.5, 32, 128, 1024, 2048	1, 1.5, 4, 8, 32, 128, 1024, 2048

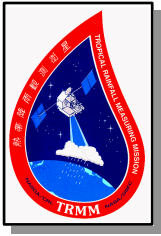


System Overview

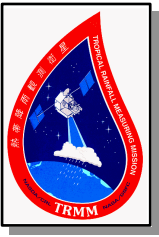


System Overview



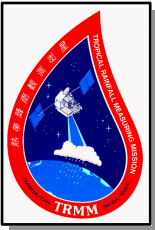


Ground System



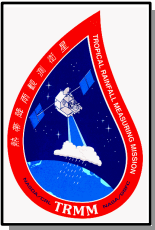
Ground System

- Re-engineered to a three server configuration without a RAID
 - Prime for RT, prime for MP, redundant for both
- Kept extra terminals from launch
- Upgraded memory on most terminals
- FTP to Langley has been temporarily fixed
 - New gatekeeper will require Formats fix
- TSDIS awaiting secure shell for remote login
 - Possibility of direct connection to MOC
- Problems
 - Regular hardware failures: disk drives, tape drives, cooling fans
 - Still getting Front End Processor and software failures occasionally
 - DKS continually having problems
 - Facility power analysis



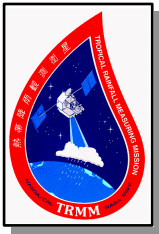
Ground System

- Sustaining Engineering
 - 4 Critical to be implemented on backup string for Y2K
 - » Oracle rollback error fixed in configuration
 - » Due for delivery to testing in November
 - Full delivery after turn of the year



Ground System

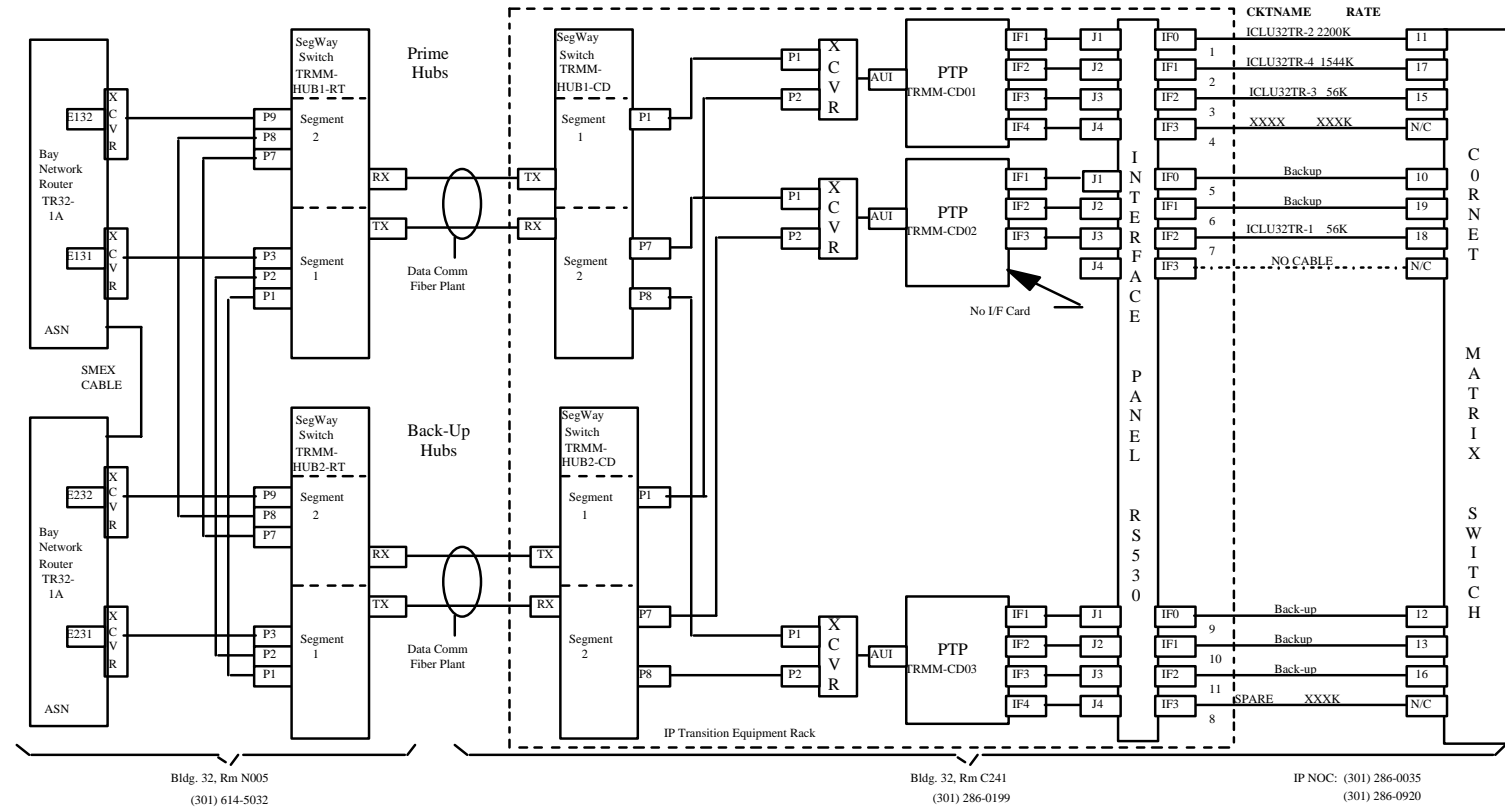
- IP System
 - Transitioned to SN and NCC IP on 98-280
 - Transitioned to GN/DSN IP on 98-306
 - Current Configuration
 - » 3 PTPs: 2 prime and 1 hot backup
 - 3 channels on each PTP connected to Cornet Switch
 - PTP Software: Version 4.05.3
 - » May require manual Y2K rollover by CD manager
 - Problems and issues
 - » PTPs require reset sometimes occurring during TDRS events
 - Authorization should be granted by CD manager
 - » Maintenance requests not always fulfilled efficiently



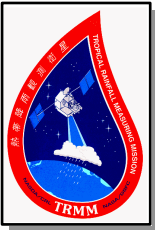
Ground System

EC No: 541-1281

EC Title: Nascom IP Transition: TRMM

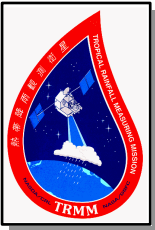


10/12/98



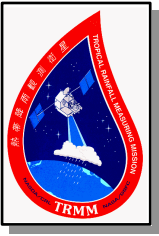
Ground System

- GTAS configuration change
 - Juke box replaced with 3 9GB drives capable of holding ~3 months of data
- GTAS Software
 - Version 6.0.1 installed in February 1999; Y2K compliant
 - No new versions will be delivered unless major DR written
- Types of Data Archive for use by GTAS
 - Hourly and daily statistics for trending mnemonics kept since launch
 - Regular telemetry of trending mnemonics kept on-line for 3 months
 - All engineering data stored on CDs made by DDF since launch
 - » Used frequently for reviewing past anomalies and trending
 - » Receive ~73 CDs per year



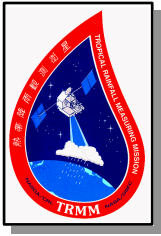
Ground System

- GTAS Operations
 - Subset and ingest of LZP file performed daily upon delivery via consim from DDF
 - Power analysis program executed daily
 - Hourly and Daily Statistics RARs run daily
 - Hourly statistical plots run weekly and reviewed by FOT engineers
 - Mission life plots updated and reviewed monthly

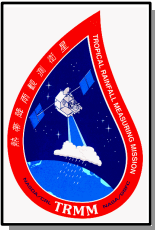


Ground System

- MOC Operational Database
 - DB 11.0 (3rd since launch): Presently being compiled
 - » Limit changes in PDB fix procedure, discrete limit changes, new pseudos
 - » Will be made operational on string 2 for verification before implementation on string 1
 - » Operational database file (Version 10.1) will be compared against new one

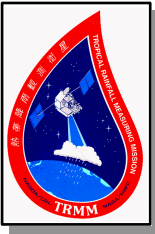


Operations



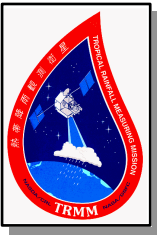
Flight Operations

- Staffing
 - 3 new Console Analysts started on July 19th
 - » Will be worked into 12 hour shifts starting August 3rd
 - All 8 Console Analyst slots filled now
 - » Hiring of 9th Analyst being considered



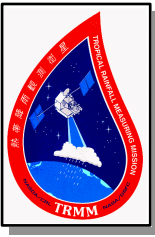
Flight Operations

- Training
 - The goal is to have all team members certified as CC
 - » Including mission planners and engineers
 - Advanced Training Program
 - » Everyone is expected to participate annually
 - » Train Console Analyst in new areas, i.e. checklists for Solar Array failure, simulations etc.
 - Review of subsystem Certification Tests performed monthly
 - » Ground System, ACS, and Deployables recently updated



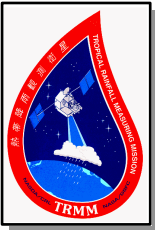
Risk Management

- Contingency trees and Console Binder:
 - Used in identifying known spacecraft/ground anomalies or problems
 - EXAMPLE: Failure to Acquire
- Local Operating Procedures (LOPs):
 - Use to retain knowledge on the TRMM project
 - Training and reference tool used in familiarizing Console Analyst with various activities and procedures
 - EXAMPLE: VIRS Reset
- TRMM Pass Plans:
 - Used in planning activities in a support chronologically
 - Used in documenting activities performed on a support
 - EXAMPLE: Extremely helpful in CERES power ON/OFF activities



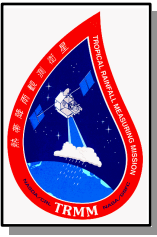
Risk Management

- TRMM developed Anomaly identification, simulation, recovery and contingency checklists
 - Purpose:
 - » To reduce Anomaly identification and recovery time
 - » To provide a systematic approach to troubleshooting
 - » To keep Console Analysts abreast with developments and changes in operations
 - » To minimize human errors, and help solve correct problems
 - » An opportunity for current and new Analysts to learn or witness uncommon spacecraft/ground problems
 - » Part of TRMM “Advanced Training Program”
 - EXAMPLE: Solar Array Checklist
- Certification Tests reviewed and updated monthly to include changes to operations



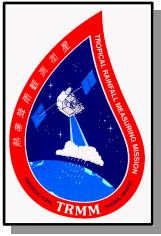
Risk Management

- Shift Handover Log and Daily Summary Reports:
 - Used in documenting all activities performed during a shift and/or activities that needs to performed by the incoming shift
 - Briefing incoming Analyst, without relying on human recollections
 - Updated to correct problems caused by poor handover information
 - EXAMPLE: Daily Load uplink
- TRMM RCCA Approach:
 - Used in determining the root cause of problems related to FOT
 - Coming up with solutions that will prevent reoccurrence
 - Event/Anomaly Reports contain fields to define whether an RCCA is required
 - EXAMPLE: Patch Load checking

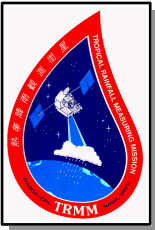


Risk Management

- MOCR process, part of TRMM configuration management
 - Ensures accurate approval of all edits, changes or developments
 - Can be initiated by any team member
 - Verified and approved by subsystem lead
 - Implemented by the System Administrator
 - » EXAMPLE: Procedure edits go through this process rigorously
- The Advanced Training program is part of the risk abatement plan
 - To keep console Analyst abreast with changes in operations
- Risk Assessment
 - Current effort is focused on establishing baseline process maps
 - ATSC *Riskcontrol* tool being used as part of effort
- On call list of all NASA and FOT subsystem engineers on console
- See Appendix for Check List, LOP and Contingency Tree samples

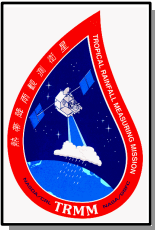


Upcoming Events



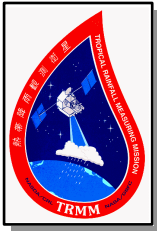
Leonids Storm

- MSFC Leonids Storm Information Center
 - TRMM will be involved in test run (Perseids Storm) on August 10-12
 - Engineering List Serve e-mail will be contact point
- Review Action Response Document from last year
- Finalize Leonid Timeline for Instrument Power OFF and ON
 - Compile Notification Distribution list for Leonids Ops Timeline
- Test all Contingency and Instrument procedures
- Implement lessons learned from last year
 - Example: Spread out instrument shutdowns over several events

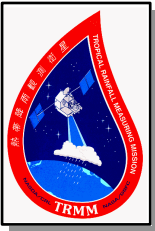


Y2K

- Mission Software and Hardware
 - Awaiting completion of final testing on string #3
 - Once accepted, system cleanup and Oracle configuration will mark readiness for normal operations
 - TSDIS direct hub connection ready for testing end of August (instead of ssh software upgrade)
 - All PCs in MOC passed Y2K and leap year rollover compliance tests
 - Recent power outages verified all essential operations components maintained required power
- First draft of Y2K Contingency Plan Completed (see Supporting Documentation)
- First draft of Y2K Ops Timeline finished and ready for review
 - Special Y2K badge on-site list being prepared



Report Statistics



Summary

- Anomaly Reports
 - 76 total; 8 opened
- Event Reports
 - 113 total; all closed
- Late Acquisition Reports
 - 34 total; all closed
- Configuration Change Requests
 - 52 total; 18 opened with 12 approved for testing